Suit Engineering & Modeling

RICHARD RHODES – SPACESUIT ENGINEER

ADVANCED SPACESUIT DEVELOPMENT TEAM

Background

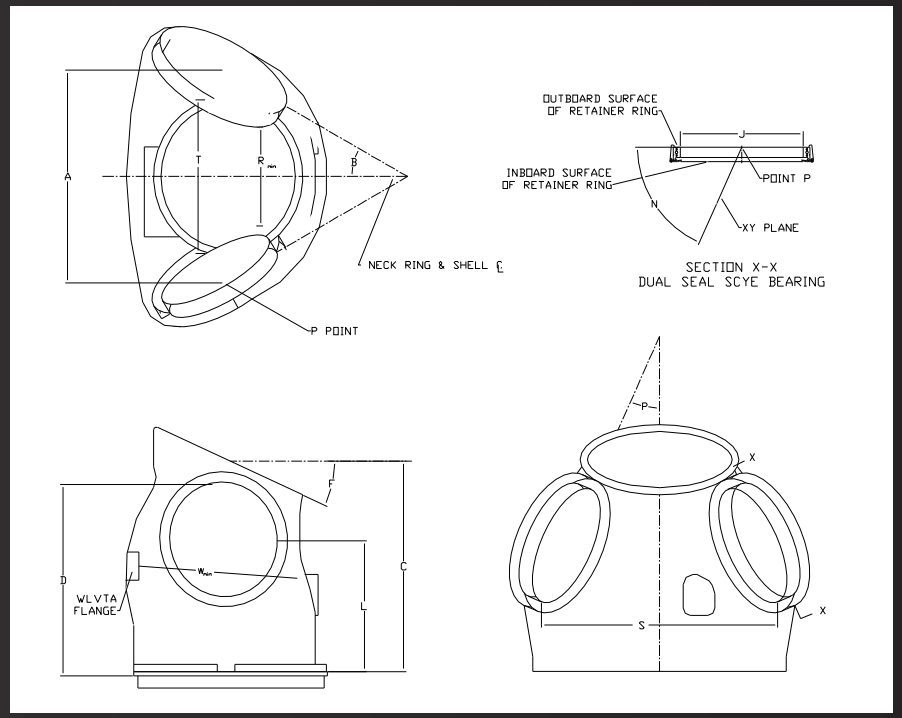
- Engineering Goal: Enable crew to perform EVA required tasks with the least amount of energy expenditure
  - If no specific tasks are identified, maximize mobility with a goal of achieving unsuited performance
- Mobility is a combination of:
  - Range of motion
  - Work or joint torque throughout that range of motion
  - Natural movement (programming)
- Mobility is also heavily impacted by fit
  - Fit is usually evaluated by how well the suit's mobility joints line up with the crew's joints throughout the required tasks

Testing Limitations

- Development budgets usually do not allow multiple sizes of suits
  - Consistent subject fit and performance can be a challenge when evaluating suit architectures
  - Iterations of joint design are expensive and slow
    - Poor concept or just poor implementation
- Modeling suit fit and mobility offers a way of evaluating fit, range of motion, and natural movement of mobility architectures without building a fleet of suits
  - Models need to be validated, but can help guide development
- Examples of modeling efforts
  - Fit for Z-2 development

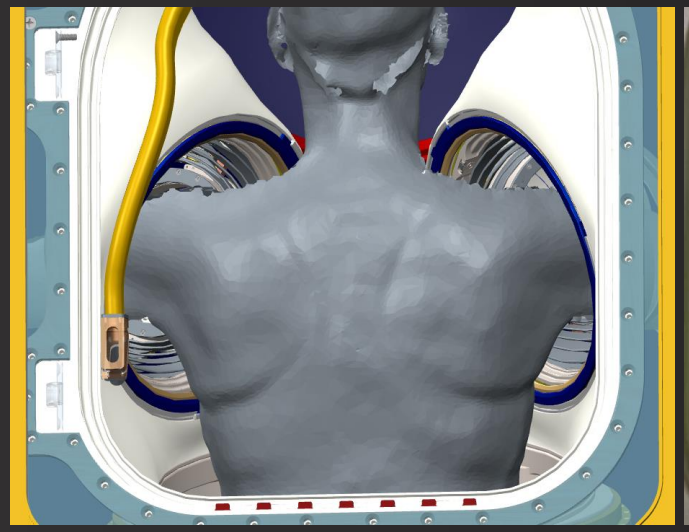
Past Sizing Method

- Historical Sizing method (Mark III & EMU)
  - Identify population to fit
  - Identify locations on the suit that correspond to the critical anthropometric dimensions
  - Validate measurements by building a mockup structure and fit checking crew population
  - Results:
    - 2D measurements offer little guidance on sizing of population
    - Fit checking crew population ensures current astronauts will fit, but is not very predictive of future sizes



Recent Modeling Based Sizing

- Z-2 Sizing Method
  - Identify population to fit
  - Obtain boundary manikins/scans to represent population
  - Conduct fit checks of manikins from entire population set in various positions
  - 3D print HUT structure and validate model results with subject fit checks
  - Results:
    - Offers better evaluation of 3D body shapes
    - Once validated, can easily fit check entire population size ranges
    - By evaluating multiple arm positions, we can evaluate good joint placement and sizes



Future Needs

- Fit – Custom or Fleet Sizing
  - Modeling analysis to produce a predicted optimal fit for custom sizing
  - Modeling analysis to produce the best sizing across a fleet of suits and the number of suits
    - Combined with mobility analysis to predict mobility when not in optimal fit
- Mobility
  - Analysis of current mobility architecture to understand what aspects of the mobility architecture or joints could be improved to offer most natural movement or most efficient interaction with crew
    - Joint angle and position
    - Joint sizing and subject indexing
    - Bearing torque